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ON THE POSSIBLE CAUSE OF CHANGES IN THE
SUN-ATMOSPHERE RELATIONSHIP

By L. A. Vitel's

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/Following is the translation of an article by
L.A.Vitel's entitled "O Vozmozhnoy Prichine
Izmeneniy Solnechno-Atmosfernykh Svyazey"
(English version above) in Meteorologiya i Gidro-
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Many investigators who have studied the relationships of various atmospheric phenomena with solar activity have noted that these relationships do not remain constant. In the course of a long period of years they can be characterized by a very high positive correlation coefficient. Then comes a time span when the sign of the relationship becomes inverse; yet even a negative correlation coefficient often has values which are indicative of a very close relationship. And then once again a direct relationship can be observed. Such changes can be repeated several times over different time intervals; sometimes, though, the relationship becomes completely unintelligible.

Naturally, such alternating character of relationships

can introduce a great uncertainty, and this fact has been employed by scientists who are sceptical about heliogeophysical relationships as an argument against the reality of such relationships.

Walker's, E.E. Fedorov's, and particularly V. Yu. Vize's investigations have in a significant degree clarified this problem. It has been demonstrated that sun-atmosphere relationships do not have to possess a universal, unchangeable character. Autonomic development of processes in terrestrial atmosphere leads to a situation where a reaction of the latter to fluctuations of solar activity can be different at different times and in different regions of the earth. The "law of the accentuation of the baric field", clearly formulated by Vize, has furthered greatly the investigation of heliogeophysical relationships; however, even he could not explain the total heterogeneity of these relationships. It should be emphasized that it has been established in several investigations, carried out in recent years, that fluctuations of solar activity are reflected not only in the intensity of atmospheric circulation (as it follows from the law of accentuation), but as well in the type of circulation; while the relationships of types and intensity of circulation with solar activity change with the course of time. An at least qualitative explanation of the causes

underlying the indicated changes in relationship becomes therefore most essential for heliogeophysics.

In the present article a hypothesis is introduced which purports to explain a principal possibility of changes of the character of sun-atmosphere relationships.

The considerations stated below do not in any degree pretend to be final and are based upon a theoretical model of the mechanism of heliotropospheric relationships, constructed by L.P. Rakipova /5,6/.

According to Rakipova's system, atmosphere above tropospheric cyclones and anticyclones is divided into several layers with the circulation sign alternating from layer to layer.

In the lower stratosphere an anticyclone is located above the cyclone; higher, a layer with a cyclonic character of circulation; still higher - again an anticyclone, and so forth. All the circulation wheels are interconnected into a single mechanism. The distribution of circulation wheels above the anticyclone is inverse to the cyclonic; that is, a cyclone is located above an anticyclone, and so forth.

We shall not currently examine all the details of this system. From our point of view (shared also by Rakipova) it is hardly possible to speak about one universal system. At a different time, or even at the same time in different regions of the earth, a different stratification of atmosphere

can take place. The principal idea of Rukipova's system is of major importance, namely the alternation of layers with different circulation signs. This system permitted the explanation of the variability, established earlier by the author /3/, of influence of solar activity on cyclones and anticyclones.

The warming up of some layer of the upper atmosphere at the expense of the energy of solar corpuscles causes in this layer a rise of isobaric surfaces and anticyclonic circulation. If, for instance, an even numbered layer is warmed up (counting from the bottom, starting at the troposphere), above the cyclone this layer is characterized by anticyclonic circulation; consequently, this circulation is strengthened as well as the circulation of adjacent layers. All of this leads to the deepening of the tropospheric cyclone.

A reverse situation will occur above the anticyclone if the even layer is characterized by cyclonic circulation. The warming up of this layer, making a tendency to anticyclonic circulation, will suppress cyclonic rotation. Vertical movements (and, connected with them, horizontal movement) in adjacent layers will weaken correspondingly. This will lead to a weakening of the total vertical complex of interconnected circulation wheels and, finally, to a weakening of the tropospheric anticyclone.

Thus, instead of a simple accentuation of circulation at the time of the outbursts of solar activity, we can observe a more complex situation when cyclones become stronger and anticyclones weaker or vice versa.

Next, deduction from Rakipova's system /6/ entails the fact that the warming up of an odd layer causes an effect that is opposite to the effect observed in the warming up of the even layer. This is an important deduction and it is taken as a basis for further deliberations.

Solar corpuscles have different velocities. It can be therefore quite naturally assumed that particles flying with great speed are able to penetrate vast thicknesses of the atmosphere.

Therefore, faster particles can reach, for instance, layer E of the ionosphere, while slower particles will have been absorbed in the F layer. Corresponding to Rakipova's system, the effect of the intrusion into terrestrial atmosphere of fast and slow particles will be different. If the former will cause, in the final count, deepening of tropospheric cyclones, then the latter, to the contrary, will facilitate the charging of cyclones. The effect on anticyclones will have an opposite character.

It should be taken into account that the given external causes act upon a mechanism, constantly functioning in the atmosphere, of interconnection of aerial currents in

cyclones and anticyclones. This mechanism compensates the loss of the masses of air in the deepening cyclones by means of a corresponding transfer of air to anticyclones; that is, simultaneously with the intensification of cyclones it causes an intensification of anticyclones or a widening of the region of their distribution.

Therefore the opposite character of the effect of solar activity in the intensity of cyclones and anticyclones is not always expressed sufficiently clearly.

The difference of the effect of corpuscular currents of different hardness is also, and for the same reason, not always clearly expressed.

An insufficiently clear situation also occurs when in the current of particles invading the terrestrial atmosphere there is no definite predominance of the hard or of the soft component; that is, when the velocities of the particles are heterogeneous. An even greater complication is introduced into the resulting effect by the appearance of secondary particles, originating under the action of solar corpuscles in upper layers of the atmosphere. Velocities of these particles, and consequently also their effect, can differ substantially from the velocities and the effect of primary particles of solar origin.

All of this greatly complicates and entangles helio-tropospheric relationships, hindering detection of that

Difference of reaction of fast and slow corpuscles about which we spoke above. Notwithstanding the increasing complexity of circumstances, however, the given effect can be verified on empirical material.

Unfortunately, we do not have yet sufficient data on direct measurement of energy and the velocities of corpuscles. Observations of that kind became possible only during a very recent time, in connection with the rapid progress in the field of rocket investigations of upper atmosphere and cosmic space. We can hope that in the near future we shall obtain by means of rocket observations rich material for the immediate comparison of corpuscle velocities. While such material does not exist, it is permissible to use indirect exponents from which it is possible to conjecture, if only very approximately, about the difference of the velocities of the corpuscles. Magnetic storms can serve as such exponents.

The author has established already in 1949 and pointed out in his report /3/ that the influences of solar activity upon atmospheric circulation during days characterized by magnetic storms of different intensity are different. In many instances the effects of storms belonging to the class of heavy and very heavy are opposite.

Let us cite some examples, corroborating this assumption.

The dates of heavy and very heavy storms for the period

from 1900 to 1939 were selected from Pavlov's catalogue of magnetic storms. The number of cases of storms of the first type appeared to be 122, of the second 56. All given dates were assumed to be the zero day. Then, for these days and also for the three preceding and three following days, mean indexes of intensity of cyclonic and anticyclonic circulation were calculated according to the method indicated in reports /2,3/. The calculation was carried out for each of the eight regions of the synoptic catalogue used by the author. Fig. 1a represents the change of the cyclone intensity index in the first synoptic region (region of the Iceland minimum) I_z^1 , and Fig. 1b, change of the same index from the averaged data of all eight regions I_z^1 I_z^8 .

As can be seen from fig. 1, sharp changes of the intensity of cyclones occur after the zero day; that is, after the intrusion into the atmosphere of the particles that have caused the magnetic storm. It can be also clearly seen that changes of the intensity of cyclones during heavy and very heavy magnetic storms have an opposite character.

Indicative is also the course of one of the combined circulation indexes; $I_z^4 + I_a^7$ as represented in fig. 2. The first component of this index represents by itself the mean intensity of cyclones in the fourth synoptic region (north of Europe), and the second component - the mean intensity of anticyclones in the seventh region (south of the

European territory of the USSR and the Caspian region). The given combined index reflects to a certain degree conditions of the West-East transfer on European territory of the USSR.

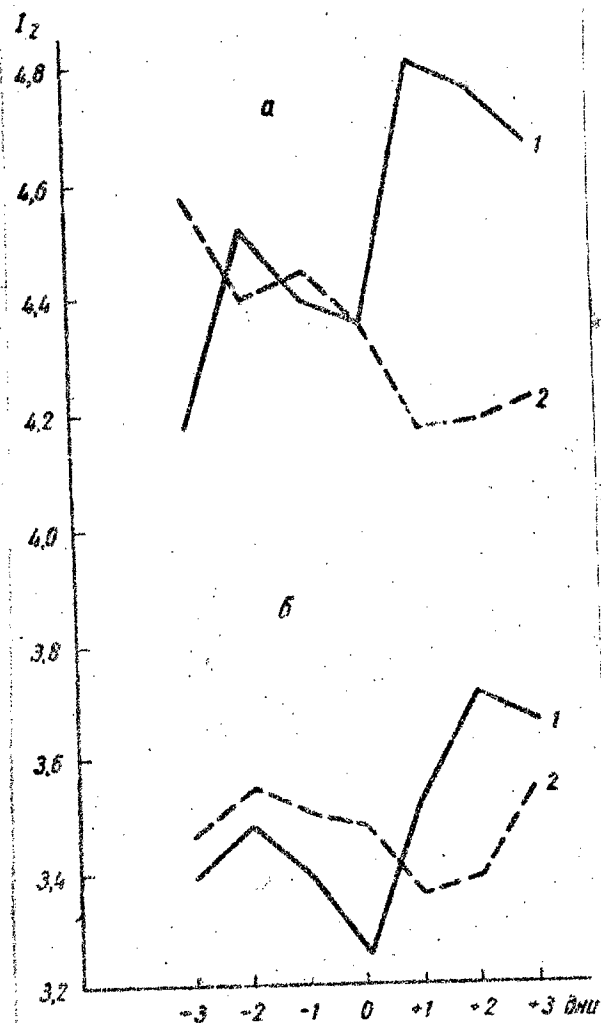


Fig. 1. Change of cyclone intensity in the Iceland region (a) in eight synoptic regions (b) during days of very heavy (1) and during days of heavy (2) magnetic storms.

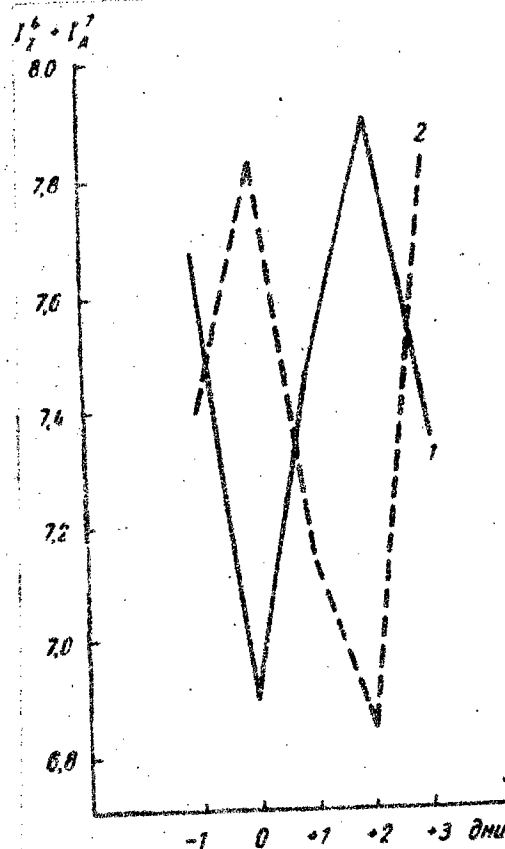


Fig. 2. Changes of the $I_1 + I_2$ during days of very heavy (1) and during days of heavy (2) magnetic storms.

As can be seen from fig. 2, the changes of this index in

heavy and very heavy magnetic storms are inverse.

The changes of the intensity of cyclones and anticyclones, computed by individual regions, are not uniform in character. The contrast of the change of these indexes during magnetic storms of different classes is not always expressed as well as on the averaged graph of fig. 1b; however, at the present stage of the investigation we did not attempt to analyze all of the details but rather to demonstrate the principal possibility of an explanation of a different effect of the outbursts of solar activity.

It can be seen from the cited examples that increases in solar activity, accompanied by the ejection of corpuscles of different energy can influence processes in the lower layer of terrestrial atmosphere in a different manner. Yet, as was demonstrated in M.S. Eigenson's /7/ and A.I. Ol's /4/ reports, corpuscular activity of the Sun changes substantially in time and systematic cyclical changes of rigidity and direction of corpuscles are discovered besides. It follows therefrom that during periods which differ substantially as to the velocity of corpuscles intruding into the atmosphere, the character of heliotropospheric relationships can be sharply different, down to a change in the sign of the given relationships from time period to time period, as well as during shorter time spans. This type of changes of sun - atmosphere relationships, in particular, can take

Place also during the transfer from one rotation of the sun to another. The origination of a powerful active focus on the sun can be accompanied by the ejection of fast corpuscles. During repeated passages through the central meridian of the hemisphere of the sun turned toward earth, this focus can be a source of a softer corpuscular radiation, and then the effect of the same active region will be different.

The hypothesis stated above is in need of further collaboration by much experimental data. Observations carried out in the framework of the IGY program assume a particularly substantial value in this respect. The era has come when direct measurement of parameters of the corpuscular radiation of the sun in cosmic space far beyond the limits of the terrestrial atmosphere is accessible. All methods of indirect determination of the velocity of corpuscles should also be widely utilized. Materials of ionospheric observations and observations of aurorae should also be encompassed, besides geomagnetic data.

Long ago, in the last century, a comparison was made of polar aurorae with weather. The new development of meteorology has brought much enrichment from many other branches of geophysics. The problem of the presence of any relationship between weather and polar aurorae or magnetic disturbances has appeared outside of the scope of scientific investiga-

tions and the very posing of this problem was considered unscientific. At the present time this problem acquires a deep physical meaning, and investigations in the given direction open new vistas in the exploration of the mechanism of sun - atmosphere relationships.

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